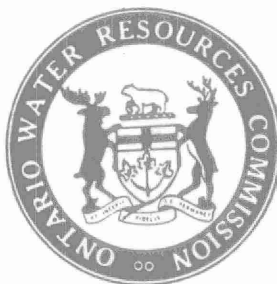


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VIRUSES IN WATER SUPPLIES AND THEIR
SIGNIFICANCE IN POLLUTION CONTROL

DIVISION OF RESEARCH
ONTARIO WATER RESOURCES COMMISSION

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VIRUSES IN WATER SUPPLIES AND THEIR
SIGNIFICANCE IN POLLUTION CONTROL

By:

A. H. Vajdic MA

April, 1968

Division of Research
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A. J. Harris
Director

Dr. J. A. Vance
Chairman

D. S. Caverly
General Manager

The Ontario Water Resources Commission

SUMMARY

Evidence for the presence of various viruses in waters is presented; the possible results of their presence and their significance is discussed, along with outlines of some of the more successful methods of isolation.

Renewed impetus has been given to research concerned with the presence of viruses in water, by the great concern which has developed regarding the deterioration in quality of many of the sources of fresh water available for human consumption. The re-use of water is now common practice; the sewage discharged from the outfalls of one urban area, after varying degrees of treatment, is taken in, albeit somewhat diluted, to the water supply intakes of the community downstream. In some cases, no treatment is afforded wastewater before discharge into receiving waters; in others there are standards of quality which 'used' water must meet, subsequent to treatment. However, there is a good deal of evidence (1,2,3) that the parameters now used to indicate the absence of human pathogenic microorganisms from such waters are not adequate with respect to viruses; a recent report shows that they are insufficient even for some bacterial pathogens (4). Thus, the reduction of numbers of coliform bacteria during any treatment process, is not paralleled by a reduction in viruses. Indeed, some treatment processes (5) have no significant effect on the virus content, whereas others (6) will only yield reductions of 90% or more, if operated under optimal conditions, which are rarely attained in practice. Even post-chlorination may fail to result in virus-free

effluents, since many viruses require high chlorine residuals under controlled pH conditions, with extended contact times, before inactivation is achieved (7,8). In the case of recreational waters, dissemination of any viruses which can gain access to the water from the eyes, nose, skin or urine of a swimmer, may occur. Evidence of transmission in association with (9), and isolation of viruses from (10,11) recreational water exists. Here again, as in the case of wastewater effluents and potable waters, present monitoring systems are not sufficient to safeguard against viral contamination. There is also the interesting speculation regarding the presence of non-human viruses in natural waters. Such viruses would gain access by means of rural and urban runoff, and in wastewaters from food processing and packing plants. Little investigation has been made into the presence of these viruses in water, their effects on the flora and fauna or their possible effect on humans. It is known that cancers may be produced by inoculating viruses from one animal species into another, non-related, species. Other viruses, native to animals, may cause infection but not necessarily overt disease in man. These aspects of the problem are dealt with fully in a chapter entitled "The Viruses in Water" (12),

in a publication based on a symposium held at the R. A. Taft Sanitary Engineering Centre in Cincinnati, Ohio.

It must therefore be assumed that there is the probability of the presence of many different types of viruses in natural waters, some of which may serve as supplies of potable water; they enter via an inflow of 'used' water in the form of sewage discharge, via runoff water from land and urban areas, and by virtue of possible use in recreation. There is ample proof that viruses excreted in the feces of humans are present in such waters (13,14,15). It is obvious however, that due to treatment processes generally applied to waste and recreational waters, these viruses will be present in fairly low numbers. Dilution, also, plays a major part in removing viruses to a non-infective level (16). There are two direct results of this occurrence of viruses at low levels.

Firstly, the typical explosive epidemic normally associated with water-borne transmission may be absent, since relatively few individuals would be exposed to very small quantities of virus. Thus, in spite of the highly infectious nature of some of the viruses, inapparent infections may result from the ingestion of minimal quantities of virus, or symptoms develop that are so mild as to be regarded by the

individual as unreportable; such infections may manifest themselves as gastro-enteritis or summer diarrhoea, for which, as yet no etiological agent has been identified. The problem is further complicated by the occurrence of immunity or partial immunity, in most communities, to at least some of the viruses, such as the poliomyelitis virus. The occurrence of disease in the form of such inapparent or mild cases does not diminish its importance, since contact transmission of the virus may result from the initial infections and could be considerable. The epidemiological picture resulting however, would be one of person-to-person spread. Such an hypothesis of initial infection via water, followed by contact transmission has been put forward by Taylor et al (17) to explain the endemic spread of infectious hepatitis. Therefore, the fact that unequivocal epidemiological evidence for the water-borne spread of viruses is lacking, except for infectious hepatitis (18), does not necessarily indicate their absence from water supplies.

Secondly, the detection of low numbers of viruses in large volumes of water presents enormous technical problems. Viruses survive, but do not multiply outside living cells;

tissue cultures (mono-layers of various types of animal cells grown in test-tubes) are employed to detect them, and the techniques required are highly skilled and expensive. There has, as yet, been found no virus which can be used as a reliable indicator of the presence of other viruses, except under experimentally controlled conditions (19). Consequently, the viruses themselves must be isolated, and the problem is one of concentrating them sufficiently; it has been calculated (20) that the average density of enterovirus, even in sewage, is 500 virus particles per 100 ml and in polluted waters only 1 per 100 ml. Therefore concentrations of at least one hundred fold are required, even in the case of highly polluted waters.

One of the methods which has proved successful is that of suspending a swab of cotton gauze in the stream flow for a given length of time. The fluid expressed from the swab may then be treated in further ways to concentrate any virus which has been trapped. These include the use of ion exchange resin (21), ether-treatment followed by ammonium sulphate precipitation (22) or ultra-centrifugation (23). Such methods were used successfully to determine the safety of the Santee, California recreational water project (24);

but it was estimated that 1 TCID₅₀ per ml (TCID₅₀ - that amount of virus which would, on the average, infect 50% of the tissue cultures inoculated with it) of virus was required (25), before the method would detect its presence. This would be below the sensitivity required for a monitoring procedure, according to the above estimate. The method is also non-quantitative, in that it is not known how much water passes through the swab, before it is tested. A modification of the technique (26), does allow such measurement, and viruses have been isolated by this means from a known volume of the tap water of a large city. Recently, other methods of recovering small numbers of viruses from large volumes of water, have shown success; these include the use of membrane filters (27,28), the use of the actual water sample to prepare the fluid used for the growth of the tissue cultures (29) and isolation by means of soluble, alginate filters (30). The latter method, using soluble filters was used successfully in the isolation of poliovirus from swimming pool waters (10). These methods are currently being developed to enable their application to routine studies.

There is as yet, no accepted method of examining waters for the presence of viruses, which is quantitative, and at the same time sufficiently simple and inexpensive to

be used as a routine procedure. When such a method is found, the detailed study of the presence in water of not only those viruses which are pathogenic to man, but also those native to domestic and wild animals and plants can proceed. The Ontario Water Resources Commission is at present investigating possible isolation methods, with a view to setting up virological surveillance programmes. When this point is reached, sufficient research should reveal whether or not water-borne transmission does occur to a significant degree. Then, the dangers inherent in the re-use of water or its initial pollution will be known, and treatment methods and water quality standards may be adjusted accordingly.

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